[10191/2225]

ELECTRONICALLY COMMUTATABLE MOTOR

Field Of The Invention

The present invention relates to an electronically commutatable motor, whose excitation windings are controllable via semiconductor output stages by an electronic control unit with the aid of PWM control signals. A setpoint value can be specified to the control unit, and the control unit emits corresponding PWM control signals to the semiconductor output stages. A motor characteristic curve, from which an assigned nominal operating speed is derivable for the setpoint value is stored in the control unit, and the derived nominal operating speed can be compared to the actual speed of the motor. If a predefinable or predefined speed difference between the nominal operating speed and the actual speed is exceeded, the control unit and/or the semiconductor output stages can be switched off.

Background Information

A conventional electronically commutatable motor is described in German Published Patent Application 198 04 874. In that case, the PWM control signals are established in their pulse width by the input of the setpoint value. The comparison of the nominal operating speed, which is assigned to the setpoint value, to the actual speed, is used during the continuous running operation for detecting sharp increases of the setpoint value acting from outside, in order to set the pulse

Storage of the characteristic-curve data of a motor in a memory of the control unit and use of the characteristic-curve data for deriving an operating value is discussed to some extent in the U.S. Patent No. 5,901,286 and European Published Patent Application No. 0 886 057. In these references, a characteristics field having a plurality of value pairs is used, from which the desired nominal operating value can be derived by interpolation onto a third coordinate. However, this requires a considerable expenditure of memory, particularly when the load of the motor changes.

The object of the present invention is to provide a motor of the type mentioned at the outset with simple data in the control unit, which, with minimal expenditure, for a predefined load, significantly simplifies the derivation of the nominal operating speed corresponding to a predefined setpoint value.

Summary Of The Invention

According to the present invention, this objective is achieved by storing the motor characteristic curve only as a three-dimensional characteristics field having four corner points, which, through coordination with the smallest pulse width and the limiting values of the supply voltage, as well as with the largest pulse width and the limiting values of the supply voltage, are determined by the nominal operating speeds assigned in each case. The nominal operating speed for the comparison to the actual speed is derivable as a function of the existing supply voltage, the predefined setpoint

In this context, advantage is taken of the fact that in many cases, the motor is always loaded with the same

coordinate values of the characteristics field take into account not only the pulse widths of the PWM control signals corresponding to the predefinable setpoint values, but also the fluctuations of the supply voltage, and define a characteristics field which allows a clear and simple derivation, i.e. calculation of the assigned nominal operating speed, for the supply voltage present in each case and the control conditions, the connecting lines of the corner points of the characteristics field giving the stipulations for a grid, and thus facilitating the derivation of intermediate values in the coordinate directions for the supply voltage (e.g. x-coordinate) and the pulse widths (e.g. z-direction), and leading to the sought nominal operating speed (in the y-direction).

Depending upon the use of the motor, according to a further embodiment, the four corner points of the characteristics field may be determined for a predefined motor load. The motor can then be designed in a simple manner for a different load, i.e. consumer.

In this context, according to one refinement of the present invention, the comparison between the nominal operating speed and the actual speed is able to be carried out continually during the continuous running of the motor or repeated at time intervals.

The setpoint value may be specifiable manually in a simple manner using a potentiometer, the control unit being able to be supplied with a variable setting signal which is used for the emission of allocated PWM control

motor characteristic curve and utilized for the comparison with the actual speed of the motor and ...

different ways.

For the comparison of the nominal operating speed and the actual speed, the control unit is coupled to a comparator unit which may be integrated into the control unit.

So that the overload protection does not react to short interference pulses of the actual-speed measurement, one embodiment of the present invention provides for the control unit and/or the semiconductor output stages to be switched off in a time-delayed manner.

If a run-up phase precedes the continuous operation of the motor, then the overload protection may be designed so that the comparison of the nominal operating speed and the actual speed is first able to be initiated and carried out after a run-up phase of a predefined duration has expired, so that an inadvertent shut-down does not occur during this operating phase. The run-up phase may be preset by the control unit, and the amplitude of the pulses and the pulse width of the PWM control signals, as well as their commutation frequency may be used as parameters. The run-up phase of the motor is able to be initiated with the switch-on of the control unit and/or the semiconductor output stages, and/or the input of a setpoint value for the control unit.

Brief Description Of The Drawings

Figure 1 shows a block diagram of the functional units of an exemplary motor according to an embodiment of the present invention.

As the block diagram according to Figure 1 shows, the motor unit includes an electronic control unit STE which is assigned a comparator unit VE. For a desired continuous operation, a correspondingly adjusted setpoint value $N_{setpoint}$ is specified and provided to this control unit STE. Consequently, after a run-up phase, correspondingly dimensioned PWM control signals pwm are emitted to semiconductor output stages EST which energize the excitation windings of motor M according to the pulse widths of these PWM control signals pwm. An actual speed N_{actual} thereupon sets in at motor M that is detected and supplied as a signal to a comparator unit VE which may be integrated into control unit STE. Control unit STE stores a motor characteristic curve which allows the derivation of a nominal operating speed n_x for each setpoint value $N_{setpoint}$. This nominal operating speed n_x is obtained more or less exactly in the case of the predefined setpoint value $N_{setpoint}$ if control unit STE, semiconductor output stages EST and motor M are operating correctly, and no conditions exist which lead to a drop in actual speed N_{actual}.

Nominal operating speed n_x, like actual speed N_{actual}, is supplied to comparator unit VE, and a speed deviation ΔN is ascertained. If actual speed N_{actual} is more than a predefined or predefinable speed deviation ΔN below expected nominal operating speed n_x, then a fault exists which can lead to an overload during continuous operation. Therefore, comparator unit VE generates a switch-off signal AB via which control unit STE and/or semiconductor output stages EST can be switched off, as

If setpoint value $N_{setpoint}$ is changed, then PWM control [illegible] speed N [illegible] motor M

speed n_x is supplied to comparator unit VE, and the comparison is carried out in the same manner for the new continuous operation with altered speed.

The switch-off of control unit STE and/or of semiconductor output stages EST may also be initiated in a delayed fashion, in order to suppress spurious peaks in the derived and detected speed values.

Permissible speed deviation ΔN may also be made a function of the magnitude of predefined setpoint value $N_{setpoint}$ and the existing magnitude of supply voltage u_x. The comparison by comparator unit VE may be carried out continually during the continuous operation, or repeated at time intervals. In addition, the overload protection by the comparison and the shutdown may first be switched to effective after reaching the nominal operating speed specified by the setpoint value, i.e. after a predefined or predefinable run-up time has expired. In this context, the run-up time may be started with the switching-on, that is to say, with the feeding of supply voltage u_x to control circuit STE and/or to semiconductor output stages EST, and/or with the application of a predefined setpoint value $N_{setpoint}$ to control unit STE.

Nominal operating speed n_x, derived and calculated by control unit STE, is a function not only of existing supply voltage u_x with its limiting values u_1 and u_2, but also of stored speeds n_{11}, n_{12}, n_{21}, n_{22} of the corner points of characteristics field KF, as the specification $n_x=f(N_{setpoint}, u_1, u_2, n_{11}, n_{12}, n_{21}, n_{22})$ in the Figure

according to Figure 2 shows, the voltage range from U ... is plotted in the x direction, while the pulse

the exemplary embodiment, $U_{max} = 13V$ and $U_{min} = 8V$ are selected, and the pulse width has a range from $pwm_{min} = 60\%$ to $pwm_{max} = 100\%$. For the smallest supply voltage, given $pwm_{min} = 60\%$ and $pwm_{max} = 100\%$, nominal operating speeds of $n_{11} = 50\ min^{-1}$ and $n_{21} = 1800\ mm^{-1}$ result, while for the greatest supply voltage, given $pwm_{min} = 60\%$ and $pwm_{max} = 100\%$, nominal operating speeds $n_{12} = 150\ min^{-1}$ and $n_{22} = 2900\ min^{-1}$ result. These nominal operating speeds n_{11} to n_{22} define the four corner points P1 to P4 in three-dimensional characteristics field KF. The connecting lines between corner points n_{11} and n_{21}, n_{11} and n_{12}, n_{21} and n_{22}, and n_{12} and n_{22}, respectively, permit the formation of a grid which, for existing supply voltages U_x and pulse width pwm_x corresponds to a setpoint value. Formation of the grid allows the derivation of allocated nominal operating speeds n_x on straight line $n1_x - n2_x$. Thus, given a supply voltage of $U_x = 10.5V$ and a pulse width of approximately 87%, a nominal operating speed of approximately 1800 min^{-1} can be interpolated from characteristics field KF.

This characteristics field KF is valid for a specific motor for a predefined, constant load. For a further load, a characteristics field KF valid for the further load can be stored in control unit STE.

As the three-dimensional characteristics field KF according to Figure 2 shows, supply voltage u_x having the voltage range from smallest supply voltage $u_1 = 8V$ to greatest supply voltage $u_2 = 13V$ is plotted in the x-direction. In the z-direction, pulse width pwm of the

Limit operation cases are ascertained with u and pwm, u and pwm, u and pwm, as well as u and pwm, which lead

consequently define characteristics field KF according to Figure 2.

If motor M is loaded with a different load, then a similar characteristics field KF results having new nominal operating speeds n_{11}, n_{12}, n_{21} and n_{22}.

The following values result for characteristics field KF of an exemplary embodiment shown in Figure 2:

n_{11} = 50 min^{-1} at u_1 = 8V and pwm_1 = 60 %
n_{12} = 150 min^{-1} at u_2 = 13V and pwm_1 = 60 %
n_{21} = 1800 min^{-1} at u_1 = 8V and pwm_2 = 100 %
n_{22} = 2900 min^{-1} at u_2 = 13V and pwm_2 = 100 %

Characteristics field KF can be represented as a grid, the connecting lines between corner points n_{11} and n_{12}, and n_{21} and n_{22}, respectively, as well as n_{11} and n_{21}, and n_{12} and n_{22}, respectively, specifying the gridding, and as is shown, for an existing supply voltage u_x, permitting the derivation of allocated nominal operating speed n_x in the case of existing PWM control signal p_x. PWM control signal pwm_x is allocated to predefined setpoint value $N_{setpoint x}$.

As grid line nx_1 - nx_2 shows, in the case of u_x = 10.5V and a pulse width of pwm_x = 87.5%, the derivation of nominal operating speed n_x leads to a value of approximately 1800 min^{-1}.

To calculate nominal operating speed n_x allocated to a setpoint value $N_{setpoint x}$, one proceeds as follows with

$$stg1 = \frac{n_{12} - n_{11}}{u_2 - u_1} \qquad stg2 = \frac{n_{22} - n_{21}}{u_2 - u_1}$$

$$n_{1x} = n_{11} + stg_1 * (u_x - u_1)$$
$$n_{2x} = n_{21} + stg_2 * (u_x - u_1)$$

$$stg_3 = \frac{n_{2x} - n_{1x}}{pwm_2 - pwm_1} = \frac{n_{21} - n_{11} + (stg_2 - stg_1) * (u_x - u_1)}{pwm_2 - pwm_1}$$

Thus,

$$\boxed{n_x = n_{1x} + stg_3 * (pwm_x - pwm_1)}$$

Since the calculations use the reciprocal of the speed values, the above equation for calculating surface point n_x must be changed around accordingly. With $T_x = a/n_x$, it follows that:

$$\frac{a}{T_x} = n_{1x} + stg_3 * (pwm_x - pwm_1)$$

$$T_x = \frac{a * (pwm_1 - pwm_2)}{(((stg - stg) * u - n - n - (stg - stg) * u) * pwm + (pwm * stg - pwm * stg) * u + pwm * (n - u * stg) - pwm * (stg * u}$$

In the formula above, any supply voltage U_x and the pulse

width of output-stage control pwm_x are variable. The remaining factors may be stored as fixed parameters in the ROM or EEPROM. Following is once again the same formula with the variable names used in the program code.

$$\boxed{v\_tx = \frac{K\_ZAEHL_1}{\left(\left(K\_NENN_1 * v\_ubat + K\_NENN_2\right) * v\_pwm\_endst + K\_NENN_3 * v\_ubat + K\_NENN_4\right)}}$$

During the programming at the rear end of the assembly line, the corresponding parameters can now be transferred from the test stand into the EEPROM of the motor control.

Wherein:

$$K\_NENN_1 = \left(stg_1 - stg_2\right)$$

$$K\_NENN_2 = -n_{21} + n_{11} + \left(stg_2 - stg_1\right) * u_1$$

$$K\_NENN_3 = \left(pwm_1 * stg_2 - pwm_2 * stg_1\right)$$

$$K\_NENN_4 = pwm_1 * \left(n_{21} - u_1 * stg_2\right) + pwm_2 * \left(stg_1 * u_1 - n_{11}\right)$$